Some observations on the juveniles of *Hilsa ilisha* (Hamilton) (Pisces: Clupeidae) from Godavari Estuary

BY

M. Babu Rao
Zoology Department, Andhra University, Waltair [1]

(*With a map and two text-figures*)

Introduction

This paper is a brief account of the observations made on *Hilsa ilisha* in the lower reaches of Godavari estuary during the period 1958-1962. Observations were mainly made in the Gautami branch of the estuary (Fig. 1) and some of the aspects like length-weight relationship and biometric studies were restricted to juveniles. The aspects covered by Pillay & Rao (1963) were omitted.

Material and methods

When it is about 80 km. from the sea, the River Godavari divides into two branches—the eastern branch is the Gautami and the western branch divides further into two, the Vasishta and Vainateyam (Fig. 1). The Gautami Godavari, when about 10 km. from the sea, further splits into two branches, one branch joining the sea at Bhairavapalem and the other about 15 km. to the south, at Kothapalem.

Observations were made on fishermen's catches at five fish landing centres situated in the lower reaches of the Gautami (Fig. 1). The five fishing centres are: (i) Balusutippa, located about 8 km. from the Kothapalem or southern mouth of the Gautami, (ii) Bhairavapalem, located about 6 km. from the northern mouth of the Gautami, (iii) Neellapalli situated near the field station at Yanam (Fig. 1) about 20 km. from the Kothapalem and 16 km. from the Bhairavapalem, (iv) Masakapalli, located further up, about 35 km. from the mouth and (v) Kotipalli, which is 45 km. from the river mouth. Collections of juvenile *Hilsa* and observations on adult *Hilsa* were made every week from Neellapalli and once in a month in the other fish landing centres.

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[1] Present address: Zoological Survey of India, 8, Lindsay Street, Calcutta-16

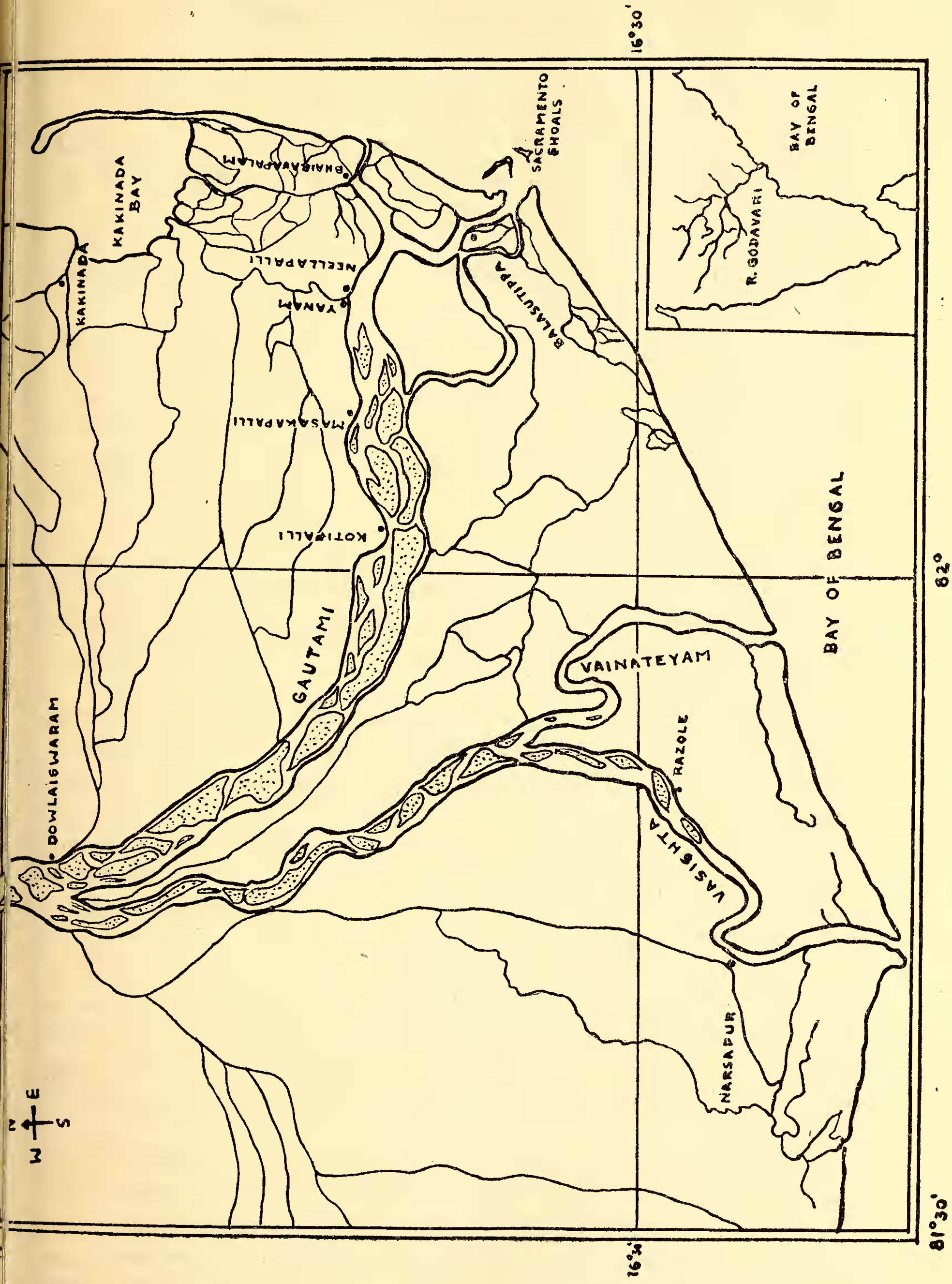

FIG. 1. THE GODAVARI ESTUARY

Length-weight data were taken in fresh condition and morphometric and meristic characters were taken in preserved condition.

Observations on the *Hilsa* fishery in the lower reaches

The general pattern of *Hilsa* fishery in the lower reaches as observed in a stretch of about 45 km. from the river mouth to (Kotipalli) up the river, is as follows : the fishery begins with the upward migration of mature adults ranging from 25 cm. to 55 cm. in length. This migration which begins in July continues until October. This is a spawning migration, as most of them are in stages V and VI of maturity and since it is correlated with the south-west monsoon, it may be referred to as the monsoon spawning migration. Sometimes in November-December, there is a lull in the fishery, marking the end of the monsoon migration. This lull is followed by another wave of upward migration of adults extending from the latter part of December to March. These migrants are more or less of the same length as the monsoon migrants, i.e. 25-55 cm. ; they may be referred to as the post-monsoon migrants.

The downward migration of the spent adults of the monsoon migration extends from October to December as evidenced by the condition of the gonads, and that of the post-monsoon migrants from April to early June. The net employed for adult *Hilsa* is the drift net called ' Rangoon net ' which is laid across the river.

In addition to the adult *Hilsa* fishery from July to early June, which involves the capture of upward migrating maturing and mature adults as well as the downward migrating spent individuals, immature *Hilsa* are caught by smaller shore seines and bottom set gill nets. Most of the fishes from these catches range from 9 cm. to 15 cm. and only a few are bigger, from 16 cm. to 19 cm. The fishery for these immature forms extends from January to June with a peak period from February to April. During the four seasons (1958-'59, 1959-'60, 1960-'61 and 1961-'62), the majority of the immature *Hilsa* caught right from January to May ranged between 10 cm. and 13 cm., indicating an extended spawning season. The general absence of juveniles below 8 cm., in the catches, can be attributed to the fact that the gill nets are very selective and also it might be that they avoid the small shore seines which do not cover the middle of the river.

Detailed account of the observations made on the migrations during the three seasons, 1959-'60, 1960-'61 and 1961-'62, is as follows :

In the 1959-'60 season the monsoon migration of the maturing adults began in July and extended till October 1959. The post-monsoon phase of the migration started in December 1959 and extended up to May 1960. The juveniles started to appear from the end of January 1960 and were in the estuary till June.

In the 1960-'61 season the monsoon migration of the adults started in July and extended to the beginning of December 1960. The post-monsoon migration of adults extended from January to April 1961. The juveniles appeared in February and extended up to July 1961.

In the 1961-'62 season, the monsoon migration of the adults started in August and extended up to the beginning of October 1961. The post-monsoon migration started towards the end of November 1961 and continued till April 1962. During this season, the post-monsoon migration period was long and accounted for an extensive fishery. The juveniles started to appear in small numbers from January 1962 till April, and then in larger numbers till the end of May 1962.

A survey made in the other two branches of the Godavari—Vainateyam and Vasishta—during the 1961 season, has shown a similar pattern except that the fishery is not so extensive as in the Gautami, which is much larger.

The two waves of migrations of adult *Hilsa* in the Godavari are similar to those observed in the Hooghly River (Pillay 1958) and Chilka Lake (Jones & Sujansingani 1951).

Length frequency

Monthly percentage length frequency curves for the juvenile *Hilsa*, purchased from the fishlanding centres were prepared for the years 1959, 1960, 1961 and 1962 (Fig. 2). In the commercial catches specimens of length 5 cm. to 19 cm. were obtained during these years and the general period of occurrence was from January to July. The occurrence of more or less the same length group in different months indicate that the spawning season is somewhat extended.

Length-weight data and morphometric and meristic data were obtained from these samples.

Length-Weight relationship

Length-weight data were obtained for the juveniles of all the four years. Of the four years, specimens obtained in 1960 were distributed in a wider length range, 6 cm. to 19 cm. in total length. Hence various regression equations have been tried on the data of this year to establish the type of equation that expresses the length-weight relationship of this species from Godavari estuary. Averages of lengths and weights were obtained for each 0·5 cm. length group and a scatter diagram was plotted. Various equations expressing different curvilinear regressions have been tried to the data (Fig. 3). The equation $W = a + b. L^3$ is found to give the best results, as is evident from comparison of the sum of squared differences of the observed and calculated weights (Table 1). The equations obtained for the juveniles of the four years are presented in

Table 2. For Hooghly *Hilsa*, Pillay (1958) has given $W=Ae^{b.L}$ as the best for length-weight data.

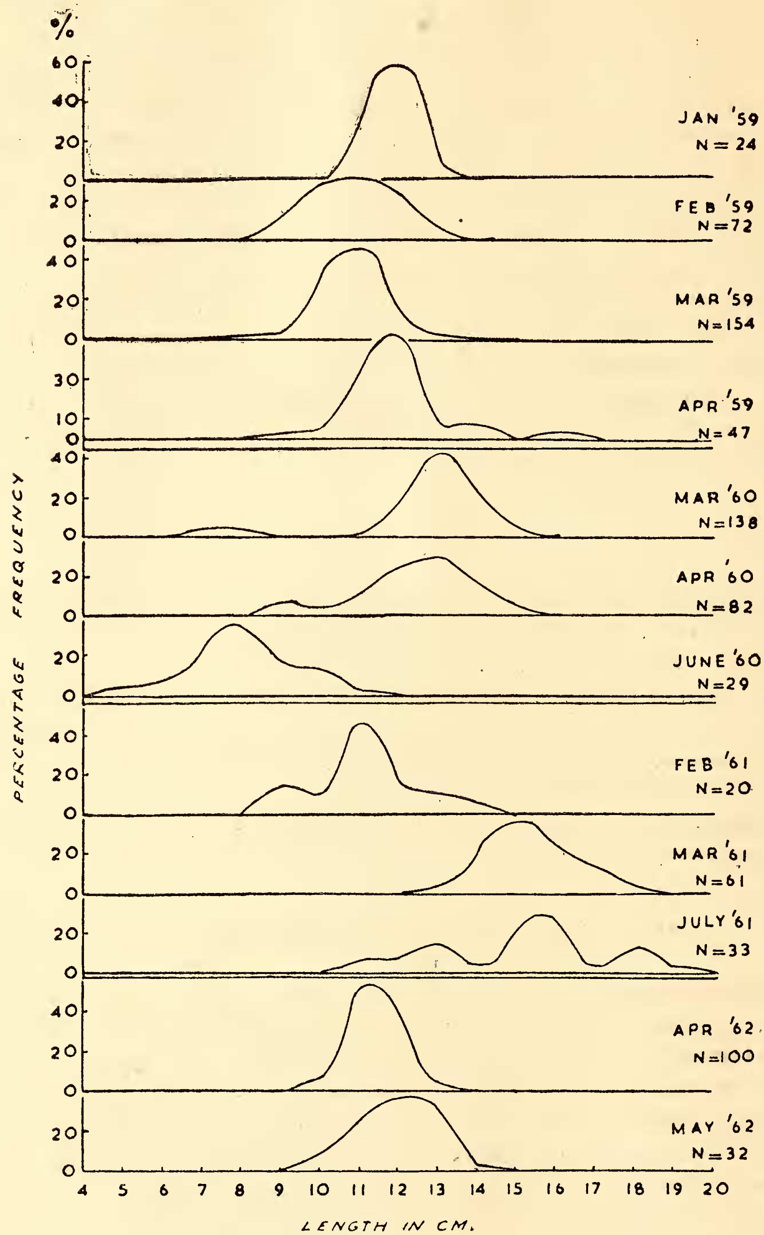

FIG. 2. HILSA ILISHA: LENGTH FREQUENCY CURVES FOR THE JUVENILES COLLECTED IN THE FOUR SEASONS.

The length-weight data of the four years (1959, 1960, 1961 and 1962) have been subjected to analysis of covariance (Goulden 1939) to see

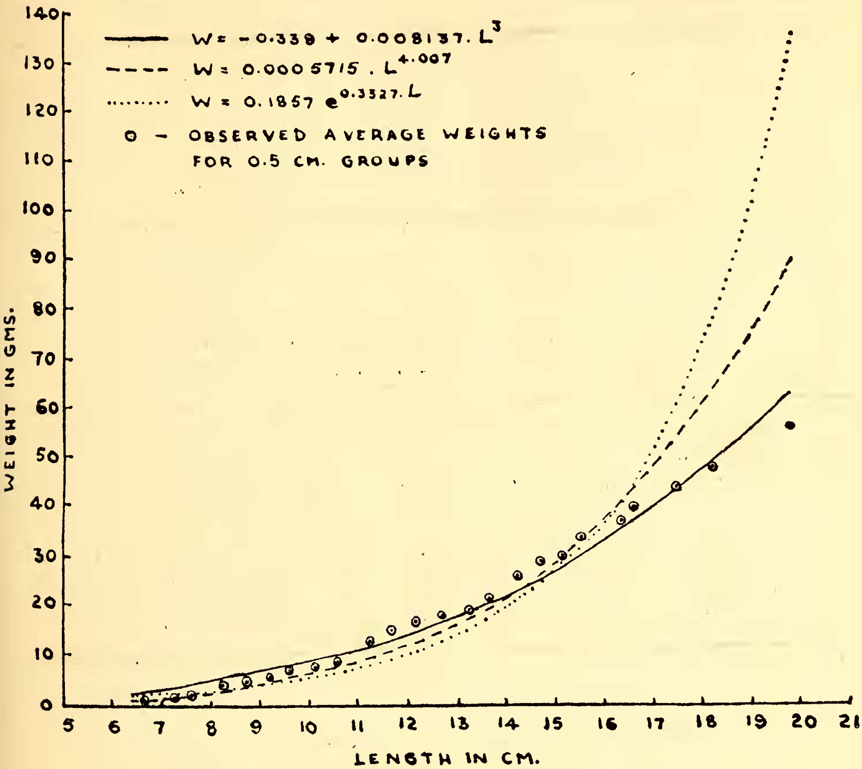

FIG. 3. LENGTH–WEIGHT RELATIONSHIP (1960 JUVENILES)

whether the juveniles of the different years (representing different year classes) belong to a homogeneous group or not with regard to the length-weight relationship (Table 3). The 'F' value was found to be significant indicating that significant differences exist between the different years. Comparison of regression coefficients of different years by means of 't' test reveals that, except for juveniles of 1959 and 1961, juveniles of any two years differ significantly from one another with regard to the length-weight relationship (Table 4). This might be due to one or both of two reasons : (i) general tendency of variation between the different year classes and (ii) difference in the environmental conditions during different years affecting the general 'condition' (well-being) of the fish which is reflected on the length-weight relationship.

TABLE 1

SUM OF SQUARED DIFFERENCES OF THE OBSERVED AND CALCULATED WEIGHTS FOR THE LENGTH-WEIGHT DATA OF JUVENILES COLLECTED IN 1960

Equation	$\Sigma(Wo-Wc)^2$
$W=c. L^n$	1,672·0546
$W=Ae^{b.L}$	7,816·0683
$W=a+b. L^3$	121·4663

TABLE 2

EQUATIONS EXPRESSING LENGTH-WEIGHT RELATIONSHIP OF JUVENILES OF THE YEARS 1959, 1960, 1961 AND 1962

Juveniles collected in the year	n	Length range	Equation
1959	95	9-14 cm.	$W=-3{\cdot}723+0{\cdot}009603. L^3$
1960	163	6-19 cm.	$W=-0{\cdot}339+0{\cdot}008137. L^3$
1961	57	13-19 cm.	$W=-2{\cdot}383+0{\cdot}009209. L^3$
1962	91	10-15 cm.	$W=\ 0{\cdot}309+0{\cdot}007224. L^3$

STATISTICAL ANALYSIS OF BIOMETRIC DATA

The biometric data obtained from the juveniles of different years were subjected to statistical analysis to see whether the species occurring in the estuary strictly belongs to a homogeneous stock or the species shows variation in the different year classes.

The following biometric data were obtained from the juveniles collected during the three years 1959, 1960 and 1961.

Meristic data :

1. Pectoral fin rays.
2. Ventral scutes.
3. Vertebrae.

Morphometric data :

1. Standard length.
2. Body depth.
3. Head length.

Data for the pectoral fin rays are available for the juveniles of 1962 season also in addition to the above three years.

TABLE 3

ANALYSIS OF COVARIANCE APPLIED TO THE LENGTH-WEIGHT DATA OF THE JUVENILES OF THE FOUR YEARS 1959, 1960, 1961 AND 1962

	(1) D.F.	(2) $\Sigma(X-\bar{X})^2$	(3) $\Sigma(x-\bar{x})(y-\bar{y})$	(4) $\Sigma(y-\bar{y})^2$	(5) b	(6) $b.\Sigma(x-\bar{x})(y-\bar{y})$	(7) $\Sigma y'^2$	(8) D.F.
1959	8	3,610,410	34,672·26	337·1530	0·009603	332·9580	4·1950	7
1960	23	91,118,020	741,459·47	6,120·9224	0·008137	6033·2557	87·6667	22
1961	10	19,398,380	178,644·00	1,654·5100	0·009209	1645·1326	9·3774	9
1962	8	4,127,934	29,821·94	216·2719	0·007224	215·4337	0·8382	7
Total	49	118,254,744	984,597·67	8,328·8573	0·008324	8195·7910	133·0663	48

(1) D.F. for unadjusted sums of squares (2) S.S. of 'x' variate (3) Sums of products (4) S.S. of 'y' variate (5) regression coefficients (7) adjusted sums of squares (8) D.F. for adjusted sums of squares.

TEST OF HETEROGENEITY OF REGRESSION BETWEEN SEASONS

	D.F.	Adjusted sums of squares	Variance	F	5% Point	Significance
Total ..	(pq-1) 48	133·0663				
Within Seasons	(pq-p) 45	102·0773	2·2684 (V_1)			
Difference	(p-1) 3	30·9890	10·3297 (V_2)	4·554	2·82	Significant

The notation used is the same as that adopted by Goulden (1939 : 253-254).

TABLE 4

TEST OF SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE REGRESSION COEFFICIENTS OF THE JUVENILES OF THE FOUR YEARS IN THE LENGTH-WEIGHT DATA

	Seasons Compared					
	1959			1960		1961
	1960	1961	1962	1961	1962	1962
σdb	0·0004868	0·0004776	0·0004462	0·0003355	0·0002885	0·000273
db	0·001466	0·000394	0·002379	0·001072	0·000913	0·001985
't'	3·011	0·8249	5·332	3·196	3·164	7·271
d.f.	29	16	14	31	29	16
P	$<$0·05	$>$0·05	$<$0.05	$<$0·05	$<$0·05	$<$0·05
Significance	Significant	Not Significant	Significant	Significant	Significant	Significant

σdb = Standard error of difference of the regression coefficients compared.
db = Difference of the regression coefficients : d.f. = degrees of freedom.
P = Probability level.

Pectoral fin rays : A comparison of the juveniles of the four years 1959, 1960, 1961 and 1962 (evidently belonging to different year-classes) by means of Chi-square test, shows significant differences in the number of pectoral fin rays (Table 5). The frequency distributions of the four year-classes reveal that the juveniles of 1961 season have a relatively lower number of pectoral fin rays than those of the other seasons. When the Chi-square test was applied to the data of 1959, 1960 and 1962 seasons (excluding 1961 season) the result was not significant indicating that only the juveniles of 1961 season show a significant difference from the others. This was confirmed by applying Chi-square test to the pooled data of the three years 1959, 1960 and 1962 on one hand and 1961 data on the other which gave a significant result (Table 5).

Scutes : When the samples of the three seasons, 1959, 1960 and 1961 were tested for homogeneity in the number of scutes (Table 6a), the Chi-square value (Table 6b) indicates, that there were no significant differences between the different year-classes.

Vertebrae : The samples of the three seasons 1959, 1960 and 1961 show heterogeneity when tested by means of Chi-square test (Table 7). When the frequency distributions of the three seasons were examined, the juveniles of 1961 season were found to have a lower number of vertebrae than the other two seasons (Table 7A). When the juveniles of 1959 and 1960 alone were tested, the result was not significant indicating that only the juveniles of 1961 season have a significantly lower number of vertebrae. This was also confirmed by taking the pooled data of 1959 and 1960 seasons on one hand and 1961 season data on the other and applying the Chi-square test. The result has shown significant difference.

TABLE 5

NUMBER OF PECTORAL FIN RAYS OF JUVENILES OF THE FOUR YEARS
(A) FREQUENCY DISTRIBUTION

Juveniles of the season	No. of pectoral fin rays				
	14	15	16	17	n
1959 ..	46	195	58	1	300
1960 ..	25	158	40	—	223
1961 ..	24	87	8	1	120
1962 ..	18	107	21	—	146

(B) Chi-square test applied to data of different seasons

Seasons compared	Obs. χ^2	d.f.	P	Significance	Remarks
(i) 1959, 1960, 1961 and 1962	14·6707	6	<0·05	Significant	In all cases classes 16 and 17 are bracketed.
(ii) 1959, 1960 and 1962 (excluding 1961 juveniles)	4·4756	4	>0·05	Not Significant	
(iii) 1959, 1960 and 1962 pooled with 1961 juveniles.	10·1702	2	<0·01	Significant	

Table 6

Total number of scutes of the juveniles

(A) Frequency distribution

Juveniles of the Season		Number of Scutes					n
		29	30	31	32	33	
1959	..	2	23	213	40	1	279
1960	..	—	9	126	40	—	175
1961	..	—	10	84	18	1	113

(B) Chi-square test applied to data of different seasons

Obs. χ^2	d.f.	P	Significance	Remarks
6·6282	4	>0.05	Not Significant	Classes 29, 30, 32, and 33 are bracketed.

Table 7

Number of Vertebrae of the juveniles of the three years

(A) Frequency distribution

Juveniles of the season		No. of vertebrae					
		44	45	46	47	48	n
1959	..	—	25	230	18	1	274
1960	..	—	13	127	14	—	154
1961	..	1	6	15	1	—	23

(B) CHI-SQUARE TEST APPLIED TO THE DATA OF DIFFERENT SEASONS

Seasons compared	Obs. χ^2	d.f.	P	Significance	Remarks
(i) 1959, 1960 and 1961 taken separately	11·3381	2	<0.005	Significant	—
(ii) 1959 and 1960 taken separately, excluding 1961	0·0021	1	>0.05	Not Significant	Classes 44, 45, 46, 47, and 48 are bracketed, in all cases.
(iii) 1959 and 1960 pooled and 1961 compared.	9·0200	1	<0.005	Significant	—

Body measurements : When the data of height on standard length from the samples of the three seasons 1959, 1960 and 1961 were subjected to analysis of covariance (Kendall 1946) a significant result was obtained (Table 8) indicating that a single regression equation will not represent all three class relations (year classes). Hence the individual year classes were compared by the 't' test (Table 9). The results show that the juveniles of 1960 and 1961 seasons differ significantly in height, while the juveniles of 1959 season do not differ from either of the other two seasons. Similarly analysis of covariance (Table 10) and test of significance (Table 11) applied to the juveniles of the above three seasons with respect to the regressions of head length on standard length, show that the juveniles of the 1959 season differ significantly from those of 1960 season, whereas the juveniles of the 1961 season do not differ from those of either the 1959 or 1960 season.

TABLE 8

ANALYSIS OF COVARIANCE : HEIGHT ON STANDARD LENGTH IN JUVENILES OF THE SEASONS: 1959, 1960 AND 1961

(a) SUMS OF SQUARES AND PRODUCTS AND REGRESSIONS

Source of variation	d.f.	S.S. x^2	S.S. y^2	S.P. xy	Regressions b
	(n_j-1)	(C_{11j})	(C_{22j})	(C_{12j})	(b_j)
Within 1959 season ..	50	45·4914	7·0644	17·3479	0·38134
Within 1960 season ..	109	445·2169	69·2573	175·1625	0·39343
Within 1961 season ..	57	42·5474	5·4405	15·0740	0·35429
	(N-p)	(C_{11a})	(C_{22a})	(C_{12a})	(b_a)
Within seasons ..	216	533·2557	81·7622	207·5844	0·38928
Between seasons ..	(p-1)	(C_{11m})	(C_{22m})	(C_{12m})	(b_m)
	2	358·8542	34·8134	108·6930	0·30289
	(N-1)	(C_{11o})	(C_{22o})	(C_{12o})	(b_o)
Totals ..	218	892·1099	116·5756	316·2774	0·35453

(b) LINEAR REGRESSIONS

Variation due to	d.f.	Sums of squares	Quotient
Deviations from linear regression within seasons	(N-2p) 213	$S_1=0{\cdot}8919$	0·00419
Differences among regressions	(p-1) 2	$S_2=0{\cdot}0617$	0·03087
Deviations within seasons from linear regression b_a	(N-p-1) 215	$S_1+S_2=0{\cdot}9536$	0·00444
Deviations between seasons from linear regression b_m	(p-2) 1	$S_3=1{\cdot}8913$	1·89131
Differences between b_a and b_m	1	$S_4=1{\cdot}6008$	1·60084
Total deviations from linear regression b_o	(N-2) 217	$S_1+S_2+S_3+S_4$ $=4{\cdot}4457$	

$$F=\frac{(N-2p)}{S_1}\times\frac{S_2+S_3+S_4}{2p-2}\text{ with (2p-2) and (N—2p) d.f.}$$

$$F=\frac{213}{0{\cdot}8919}\times\frac{3{\cdot}5538}{4}=212{\cdot}18\ ^{**}\text{ with 4 and 213 d.f.}$$

** Highly significant.
The notation is from Kendall (1946).

TABLE 9

TEST OF SIGNIFICANCE OF THE DIFFERENCE BETWEEN REGRESSION COEFFICIENTS OF HEIGHT ON STANDARD LENGTH, IN THE JUVENILES OF THE THREE SEASONS: 1959, 1960 AND 1961

	1959 and 1960	1959 and 1961	1960 and 1961
σd_b	0·01444	0·01929	0·01331
d_b	0·01209	0·02705	0·03914
t	0·837	1·402	2·941
d.f.	157	105	164
P	>0·05	>0·05	<0·05
Significance	Not Significant	Not Significant	Significant

σd_b = Standard error of difference.
d_b = Differences in the regression coefficients.
d.f. = Degrees of freedom.
P = Probability level.

TABLE 10

ANALYSIS OF COVARIANCE : HEAD LENGTH ON STANDARD LENGTH IN JUVENILES OF THE SEASONS : 1959, 1960 AND 1961

(a) SUMS OF SQUARES AND PRODUCTS AND REGRESSIONS

Source of variation	d.f.	S.S. x^2	S.S. y^2	S.P. xy	Regressions b
	(nj-1)	($C_{11}j$)	($C_{22}j$)	($C_{12}j$)	(b_j)
Within 1959 season	50	45·4914	3·4248	12·1250	0·26653
Within 1960 season	109	445·2169	37·7967	128·1175	0·28776
Within 1961 season	57	42·5474	3·4258	11·1355	0·26172
	(N-p)	($C_{11}a$)	($C_{22}a$)	($C_{12}a$)	(b_a)
Within Seasons	216	533.2557	44.6473	151.3780	0.28388
	(p-1)	($C_{11}m$)	($C_{22}m$)	($C_{12}m$)	(b_m)
Between Seasons	2	358·8542	25·1768	94·8738	0·26438
	(N-1)	($C_{11}o$)	($C_{22}o$)	($C_{12}o$)	(b_o)
Totals	218	892·1099	69·8241	246·2518	0·27603

(b) LINEAR REGRESSIONS

Variation due to	d.f.	Sums of squares	Quotient
Deviations from linear regression within seasons	(N-2p) 213	$S_1=1·6341$	0·00767
Differences among regressions	(p-1) 2	$S_2=0·0400$	0·02000
Deviations within seasons from linear regression b_a	(N-p-1) 215	$S_1+S_2=1·6741$	0·00779
Deviations between seasons from linear regressions b_m	(p-2) 1	$S_3=0·0941$	0·09405
Differences between b_a and b_m	1	$S_4=0·0829$	0·08290
Total deviations from linear regression b_o	(N-2) 217	$S_1+S_2+S_3+S_4$ 1·8511	

$$F=\frac{(N-2p)}{S_1}\times\frac{S_2+S_3+S_4}{2p-2}$$ with (2p—2) and (N—2p) d.f.

$$F=\frac{213}{1·6341}\times\frac{0.2170}{4}=7·07$$ ** with 4 and 213 d.f.

** Highly significant.

The notation is from Kendall (1946).

TABLE 11

TEST OF SIGNIFICANCE OF THE DIFFERENCES BETWEEN REGRESSION COEFFICIENTS OF HEAD LENGTH ON STANDARD LENGTH, IN THE JUVENILES OF THE THREE SEASONS: 1959, 1960, AND 1961

	1959 and 1960	1959 and 1961	1960 and 1961
σd_b	0·01029	0·01735	0·01529
d_b	0·02123	0·00481	0·02604
t	2·060	0·277	1·703
d.f.	157	105	164
P	<0.05	$>0{\cdot}05$	$>0{\cdot}05$
Significance	Significant	Not Significant	Not Significant

σd_b = Standard error of difference.
d_b = Differences in the regression coefficients.
d.f. = degrees of freedom.

Thus the above tests applied to the different morphometric and meristic characters of the juveniles collected during different seasons and consequently belonging to different year-classes, indicate that the year classes differ from one another in one or more characters. This also holds good with regard to the length-weight relationship of the juveniles of the different years.

SUMMARY

Adult *Hilsa* migrate up the Godavari during the south-west monsoon and after a brief lull, during the winter. The spent adults of the monsoon migration return to the sea from October to December and those of the post-monsoon migration from April to early June. In addition to the maturing, mature and spent adults, immature forms occur in the estuary from January to July. The Gautami branch accounts for more fishery than the other two branches of the river, Vasishta and Vainateyam.

The length-weight relationship of the juveniles of the different seasons, is expressed by the following equations:

1959 : $W = -\,3{\cdot}723 + 0{\cdot}009603.L^3$

1960 : $W = -\,0{\cdot}339 + 0{\cdot}008137.L^3$

1961 : $W = -\,2{\cdot}383 + 0{\cdot}009209.L^3$

1962 : $W = 0{\cdot}309 + 0{\cdot}007224.L^3$

Application of analysis of covariance and 't' test to the length-weight data of the four seasons has revealed that except juveniles of 1959 and 1961 seasons, juveniles of any two years differ significantly from one another.

The different year-classes differ from one another in one or more morphometric and meristic characters.

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